

JAPANESE PATENT OFFICE (JP)

PATENT JOURNAL (A)

KOKAI PATENT APPLICATION NO. HEI 7[1995]-198947

Technical Indication Section

Int. Cl. ⁶ :	G 02 B	6/00
Identification code:	301	
Sequence Nos. for Office Use:	FI	
Application No.:	Hei 5[1993]-354588	
Application Date:	December 28, 1993	
Publication Date:	August 1, 1995	
No. of Inventions:	1 FD (Total of 4 pages)	
Examination Request:	Not requested	

AN OPTICAL TRANSMISSION TUBE

[Hikaridensochubu]

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[There are no amendments to this patent.]

(54) [Title of the invention]

An optical transmission tube

(57) [Abstract]

[Constitution] In a optical transmission tube made of a transparent core material (2) and a transparent cylindrical cladding material (1) having a refractive index lower than that of the core material (2), inner surface (1a) of the above-mentioned cladding of the optical transmission tube of the present invention is formed so that it has a mean roughness of at least 0.05 μm .

[Effect] According to the present invention, it is possible to produce an optical transmission tube having high surface luminance that can be used safely in environments such as in water.

length of the tube is required; thus, for a longer tube, a higher voltage is required; therefore, in general, the length of such tubes is limited to the range of approximately 3 to 5 meters. Furthermore, due to the short circuit potential, it is not possible to use them in water; furthermore, since neon tubes are made of glass, breakage of the glass tube poses a problem.

[0003] The inventors suggested an optical transmission tube that can be used at a length of 50 m in Japanese Kokai Patent Application No. Sho 62-231904. The above-mentioned optical transmission tube can be used in water or in an environment where explosion is a possibility. Furthermore, the complex process of glass blowing required for [neon] glass tubes is not necessary, and handling is easy, but the luminous brightness is approximately 1/2 to 1/4 that of a neon tube.

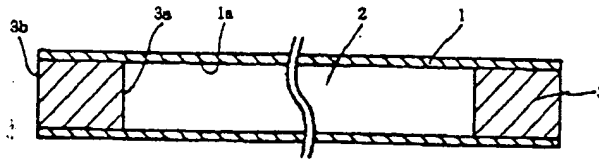
[0004] The present invention is based on the above background, and the objective of the present invention is to produce an optical transmission tube with a high luminance that can be used safely in an environment such as water.

[0005]

[Problems to be solved by the invention and effect] As a result of their continuous effort to achieve the above-mentioned objective, the inventors discovered that, in an optical transmission tube having a structure consisting of a transparent core material and a transparent cylindrical cladding material with a refractive index lower than that of the core material, high luminance can be achieved at the peripheral surface when the mean roughness Ra of the inner surface of the cladding material is at least 0.05 μm , and, as a result, the present invention was accomplished.

[Explanation of codes]

- 1 Cladding material
- 1a Inner surface
- 2 Core material



[Claims of the invention]

[Claim 1] In a optical transmission tube made of a transparent core material and a transparent cylindrical cladding material having a refractive index lower than the core material, the inner surface of the above-mentioned cladding material for the optical transmission tube of the present invention is formed so that it has a mean roughness of at least $0.05 \mu\text{m}$.

[Detailed explanation of the invention]

[0001]

[Field of industrial application] The present invention pertains to an optical transmission tube, and it further pertains to an optical transmission tube with increased luminance of the optical transmission tube produced through adjustment of the surface roughness of the inner surface of the cladding material.

[0002]

[Prior art and problems to be solved by the invention] As an historical example of an illuminant with a long luminous body, a neon tube can be mentioned. However, the neon tube requires approximately 1 kW of power per 1 meter, and a voltage corresponding to the

[0006] In the following, the present invention is explained in further detail. The present invention is: an optical transmission tube made of a transparent core material and a transparent cylindrical cladding material having a refractive index lower than the core material; the inner surface of the above-mentioned cladding material consisting of an optical transmission tube of the present invention is formed to have a mean roughness of at least $0.05\text{ }\mu\text{m}$.

[0007] An example of the optical transmission tube is shown in Fig. 1. In Fig. 1, 1 is transparent cylindrical cladding material, 2 is the transparent core material that fills cladding material 1, and 3 is a stopper.

[0008] In this case, for the material used for the hollow tubular cladding material, a material having flexibility that can be molded to form a tubular shape and having a refractive index lower than that of the core material, for example, a plastic or elastomer, etc. can be used. For specific examples of the above-mentioned materials, polyethylene, polypropylene, polyamide, polystyrene, ABS, polymethyl methacrylate, polycarbonate, polyvinyl chloride, polyvinylidene chloride, polyvinyl acetate, polyethylene-vinyl acetate copolymer, polyvinyl alcohol, polyethylene-polyvinyl alcohol copolymer, fluorine resin, silicone resin, natural rubbers, polyisoprene rubber, polybutadiene rubber, styrene-butadiene copolymer, butyl rubber, halogenated butyl rubber, chloroprene rubber, acrylic rubber, EPDM, acrylonitrile-butadiene copolymer, fluorine rubber, silicon rubber, etc. can be mentioned.

[0009] Among those listed, silicone type polymers or fluorine type polymers having low refractive indexes are especially suitable, and in specific terms, silicone type polymers

such as polydimethyl siloxane polymer, polymethyl phenyl siloxane polymer, and fluorosiloxane polymer, and polymers such as polytetrafluoroethylene (PTFE), tetrafluoroethylene-hexafluoropropylene copolymer (FEP), tetrafluoroethylene-perfluoroalkoxy ethylene copolymer (PFE), polychlorotrifluoroethylene (PCTFE), tetrafluoroethylene-ethylene copolymer (ETFE), polyvinylidene fluoride, polyvinyl fluoride, vinylidene fluoride-trifluorochloroethylene, vinylidene fluoride-propylene pentafluoride, vinylidene fluoride-propylene pentafluoride-tetrafluoroethylene three component copolymer, tetrafluoroethylene propylene rubber, fluorine type thermoplastic elastomers, etc. can be mentioned. The above-mentioned material can be used independently or a mixture of two or more different types of materials can be used in combination.

[0010] In the present invention, the mean surface roughness of the inner surface of the cladding material that comes in contact with the core material is at least $0.05\ \mu\text{m}$, and in the range of 0.05 to $10\ \mu\text{m}$ is preferable, but 0.1 to $5\ \mu\text{m}$ is especially desirable. Thus, all of the light entering from one end of the core material is not reflected at the inner surface of the cladding material, but a part of the light is efficiently transmitted through the cladding material; as a result, the luminance of the inner surface of the optical transmission tube is increased. On the other hand, when the mean surface roughness is less than $0.05\ \mu\text{m}$, the intended effect cannot be fully achieved and the objective of the present invention cannot be achieved. On the other hand, when the mean roughness exceeds $10\ \mu\text{m}$, the luminous distribution in the axial direction becomes very irregular, and only partial light emission can be achieved, in some cases; thus, it is desirable for the mean roughness to be $10\ \mu\text{m}$ or below.

[0011] As for the method used to form a mean roughness of 0.05 μm on the inner surface, for example, the conditions used at the time of extrusion to produce the tube can be changed for a fluorine type resin, or a blast treatment, etc. can be provided, and the method is not especially limited.

[0012] Also, the thickness of the above-mentioned cladding material is not especially limited, but, in general, a thickness in the range of 0.1 to 1 mm is suitable.

[0013] For the core material used to fill the hollow tube of the cladding material, a transparent solid, liquid, or fluid material having a refractive index higher than that of the cladding material is used.

[0014] In this case, for transparent solid materials, acrylic resins and methacrylic resins can be used effectively, and homopolymers and copolymers of alkyl acrylates and alkyl methacrylates such as methylacrylate and methylmethacrylate, other alkyl acrylates and alkyl methacrylates that are copolymerizable with the above-mentioned monomers and capable of producing a transparent polymer can be mentioned.

[0015] Furthermore, for specific examples of liquid or fluid type transparent materials, inorganic salt solutions, polyhydric alcohols such as ethylene glycol and glycerol, silicone oils such as polydimethyl siloxane and polyphenylmethyl siloxane, polyether, polyester, hydrocarbons such as liquid paraffin, hydrocarbon halides such as trifluorochloroethylene oil, phosphates such as tris(chloroethyl)phosphate and trioctyl phosphate, and polymer solutions diluted with an appropriate solvent, etc. can be mentioned. The above-mentioned materials can be used independently or a mixture of two or more different materials can be used in combination as well.

[0016] Stopper 3 is used even when a solid material is used for the core material, but it is essential when a liquid or fluid material is used for the core material. In this case, when the stopper is used as a window material for the light, it is necessary for the material to produce a stopper is a transparent material, and for specific examples of the above-mentioned stopper materials, inorganic glasses such as quartz glass, polycomponent glass, sapphire, and crystal, organic glasses and transparent plastic materials such as polyethylene, polypropylene, ABS resin, acrylonitrile, styrene copolymer resin, styrene-butadiene copolymer, acrylonitrile-styrene copolymer resin, acrylonitrile-EPDM-styrene three component copolymer, styrene-methyl methacrylate copolymer, methacrylic resin, epoxy resin, polymethyl pentene, allyl diglycidyl carbonate resin, spiran resin, amorphous polyolfine, polycarbonate polyamide, polyallylate, polysulfone, polyallyl sulfone, polyether sulfone, polyether imide, polyimide, polyethylene terephthalate, diallyl phthalate, fluorine resin, polyester carbonate, and silicon resin, can be mentioned. Among those listed above, inorganic glasses such as quartz glass and pyrex glass, and polycomponent glass have excellent transparency, high heat resistance, and high chemical stability, and furthermore, said materials do not react with the core material that comes in contact with them at end face 3a or glass or moisture that comes in contact with them at end face 3b; thus, long-term stability can be achieved.

[0017] Furthermore, when transparency is not required, metals and ceramics also can be used.

[0018] In general, the optical transmission tube of the present invention is formed into a tube with a cladding material having an outer diameter in the range of 3 to 110 mm,

and a length of approximately 1 to 100 m, though it is not especially limited.

[0019]

[Application examples] In the following, the present invention is explained further in specific terms with an application example and a comparative example, but the present invention is not limited to the example shown below.

[0020] [Application example] A tube with an inner diameter of 12 mm, an outer diameter of 14 mm, a length of 5 m, and having a mean surface roughness (Ra) of the inner surface of approximately 0.6 μm produced by extrusion molding PFA ($n=1.35$) at a thickness of 1 mm (cladding material) was filled with trioctyl phosphate (core material), both ends were subsequently closed with a quartz rod to produce an optical transmission tube.

[0021] [Comparative Example 1] The thickness of the tube (cladding material) was changed to 0.5 mm, and the mean surface roughness (Ra) at the inner surface was changed to approximately 0.03 μm , and an optical transmission tube was produced as above.

[0022] Subsequently, light (metal halide lamp, 150 W) was applied from one end of the optical transmission tube produced above, and the luminance at a distance of 2 m from the end was measured. A luminance meter (CS-100) produced by Olympus Corp. was used, and the measurement was performed at a location approximately 1 m away from the tube. The results obtained are shown in Table I.

[0023]

[Table I]

Distance from the end	2m
Application Example	1500 cd/cm ²
Comparative Example	160 cd/cm ²

[0024] As shown above, it was confirmed that the peripheral surface of the optical transmission tube has high luminance.

[0025]

[Effect of the invention] According to the present invention, it is possible to produce an optical transmission tube having a high surface luminance that can be safely used in an environment such as in water.

[Brief description of the figure]

[Fig. 1] The figure shows the cross section of an application example of the optical transmission tube of the present invention.

[Explanation of codes]

1 Cladding material

1a Inner surface

2 Core material

[Fig. 1]

